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# Optimization of drilling parameters to minimize burr by providing back-up support on aluminium alloy

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**Abstract**

Drilling a hole usually leaves behind a undesirable burr at the exit work surface. Application of the method suggested by Taguchi is made in this work to minimize drilling burr of an aluminium alloy using HSS drill within the domain of experiments considered. Parameters used are cutting velocity, feed and machining environment. The effect of process variables on burr height is explored, and the optimum condition for minimizing burr height using a back-up support is determined by the analysis. Experimental runs were chosen following$L_{27}$ orthogonal array of Taguchi. Analysis of variance was undertaken to find out the influence of process parameters on the response noted. Predicted values are finally checked for accuracy through a confirmation test. It is found out that back-up support yields much better result than that of normal drilling process. Moderate cutting velocity, low feed and wet condition with water cooling were observed to minimize burr height using a back-up support. Machining environment is found to be the most significant parameter for reducing burr height.


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*Keywords:*Drilling; burr; burr height;burr minimisation; Taguchi method; ANOVA; back up support.

## 1. Introduction

Drilling burr poises significant problem in the manufacture of mechanical components. Burr is plastically deformed work piece material that is attached at its edge. Undesired projection of material (burr) tends to lower part quality and does not facilitate easy assembly. Burr formation in drilling is a major problem in precision engineering, which necessitates additional cost of deburring. Though deburring can be considered as a process to solve the problems related to burrs as suggested by Gillespie [1] and Takazawa [2], it is not suitable to remove burrs from

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inside a cavity or a hole [3]. Minimization or eradication of drilling burr is, therefore, of utmost importance as proposed by Gillespie and Blotter [4] and Ko and Dornfeld [5].

Understanding the mechanism of burr formation helps one to adopt ways to prevent or, at the best, reduce burr formation. Analytical modeling, investigating tool/workpiece interaction and finding out the influence of workpiece material under varying cutting conditions facilitate understand creation of burr. Several studies examined effects of machining and other parameters on drilling burr formation for varying workpiece materials. Shape of a burr is described by its height, thickness, root thickness and radius. Nakayama and Arai [6] worked on mechanism of burr formation in machining, and tried to find out the condition giving improved quality of machined edge. Dornfeld [7] stated that different available strategies, models and data bases could be used to eliminate, or substantially reduce, burr formation. Kim [8] investigated drilling burr formation on Ti-6Al- 4V titanium alloy, and found that final shape of burrs mainly depends on heat generation due to friction between the drill and workpiece during drilling. Hewson [9] carried out experimental work on drilling of Ti-6Al-4V and identified the relationship between size of exit burr, cutting fluid, supporting back plate material, and tool geometry allowing a further understanding of the formation modes of burrs between layered materials. Both back-up plate and cutting fluid play important role in formation of uniform burr. Roy et al. [10] did experiments to observe the influence of exit edge bevel of steel flats and use of a back-up flat on burr formation in drilling under varying cutting velocities and feeds in dry and wet environment. They got quite satisfactory results by providing an exit edge bevel angle of $31^0$ and back-up material along with the application of cutting fluid for low carbon steel specimens. Ko et al. [11] studied experimentally the effect of drill geometry towards burr minimization. A large point angle was found to reduce burr size. With the increase in point angle, plastic deformation becomes localized along the hole periphery. This causes initiation of crack there resulting in uniform burr. In another work, effect of drill diameter on burr size was investigated by Naugebauer et al. [12]. Abdel [13] found out a pre-drilled pilot hole to suppress size of burr. It was also noted that chamfering on a predrilled hole eliminated entrance as well as exit burr.

Most of burr-related studies done previously were based on experimental works. A competent analytical model can provide a more detailed understanding of burr formation mechanism as well as relative influence of parameters as done by few researchers. An analytical model was developed by Kim and Dornfeld [14] related to drilling burr of ductile materials, such as low alloy steel, while Pande and Relekar [15] proposed empirical relationships and simulation tools by investigating effects of drilling variables on burr height and thickness. They found larger drills to produce increased burr height due to requirement of an increased thrust. Prediction of burr size could well be made with the simulation tool. Saunders [16] made finite element analysis to model burr formation, Min et al. [17] introduced a general FEM for burr formation in metals, while Lauderbaugh [18] investigated the effect of process variables on formation of drillburr at the exit edge through simulation and experimentation, and found reduced drill burr size with a reduced length of chisel edge. Appropriate selection of point angle was also noticed to have an effect on burr formation. In a different approach, drilling burr control chart was developed [19-20] to predict and control burr size.

Some researchers took help of optimization and modeling tools, such as Taguchi's orthogonal array, response surface methodology, etc. for designing experiments [21-24], genetic algorithm (GA) [25,26], artificial neural networks [27,28], fuzzy logic [29], and many others for making models to predict and minimize burr formation.

Less weight and good machinability are the main two characteristics due to which the use of aluminium alloys in various industries increases steadily. Ductility is another property associated with aluminium that leads to easy plastic deformation and hence, large size of burr. The more a tool approaches workpiece edge, the more the workpiece corner pivots with the chip resulting in increased burr size. However, one way of reducing burr formation is to choose tool path such the tool does not exit a workpiece. To reduce burr size, drilling was designed with the help of back-up support, i.e. an additional plate provided below the main plate where drilling arises. Objective of the present work is to undertake investigation the effect of different machining conditions and environment on drilling burr formation, and to select the optimal condition to suppress burr formation significantly in aluminium alloy using a back-up support technique.

## 2. Taguchi method

The methodology proposed by Taguchi [30,31] is widely used to design experimental runs based on orthogonal array(OA).It provides quite a less number of experiments. The orthogonal array provides the facility to select a set of minimum experimental runs. Signal-to-noise (S/N) ratio is used in this method as a measure of performance. It is a logarithmic function of output desired and is the objective function to go in for optimization. The mean and the variability are taken into account by S/N ratio. It is ratio of mean (signal) and standard deviation (noise). Quality characteristic of S/N ratios used are: lower-the-better (LB), higher-the-better (HB) and nominal-the-best (NB). When S/N ratio is maximized, corresponding parameter combination becomes the optimal setting. For solving burr minimization problem, LB characteristic is to choose. Analysis of variance (ANOVA) [32] is performed next to evaluate significance of process parameters. Through observation of S/N ratio and ANOVA, optimal set of process parameters is selected. A confirmatory experiment is carried out to justify the selection of optimal process parameter combination.

## 3. Details of experiment

### *3.1. Experimental set-up*

The experimental investigation presented here was carried out on a radial drilling machine (Make- Energy Limited, India) under dry, wet with water and wet with soluble oil conditions. Aluminium alloy flats werechosen for through-hole drilling experiments. Flats had the size of 100 mm× 50 mm× 5 mm. Drill bit used was 9 mm diameter taper shank uncoated twist drill made of HSS**.** To minimize burr, an additional plate was provided at the rear end to restrict the tool to come out from the workpiece surface freely.

Table 1. Experimental conditions

| | |
|---|---|
| Machine tool | Radial drilling machine, Make: Energy Limited, India, Model: RDH-32/930,<br>Power rating of main motor: 5 kW |
| Tool holder | R/L 265 ME-20 AL, Make: Sandvik Asia Limited, India |
| Cutting tool | Addison & Co. Ltd., Chennai, India make uncoated 9 mm diameter taper shank HSS twist drill |
| Workpiece material | Aluminium alloy, hardness: 153 HB<br>Composition: Cu (0.1%), Fe (0.74%), Mg (0.6%), Zn (0.28%), Pb (0.02%), Si (0.37%) and Al (remainder)<br>Size of flat: 100 mm x 50 mm x 5 mm |
| Back-up support material | Same as workpiece material |
| Cutting velocity | 12.5 m/min, 20 m/min and 32 m/min |
| Feed | 0.032 mm/rev, 0.08 mm/rev and 0.125 mm/rev |
| Cutting environment | Dry, wet with water, and wet with soluble oil |

Although a burr size can be characterized by its thickness and height, in the present work, burr height is considered to characterize a burr in line with many other works reported earlier. Height of drill burr was measured using a Mitutoyo, Japan make vernier caliper. Measurement of burr height around a drilled hole was made at four locations for each sample, and average of these was considered for the analysis. The workpiece material along with its chemical compositions, characteristics of tool and detail of experimental conditions are listed in Table 1.

### *3.2. Designing for experiments*

There are several factors (process variables) that can control burr size (response) in drilling. However, through literature review, following three parameters are found to be quite important to control burr height- (A) cutting velocity, (B) feed and (C) machining environment. These three factors and their interactions are primarily considered in the present work. Table 2 shows design factors chosen and their levels. In the present work, response variable is burr height in drilling aluminium alloy flats. Process parameters in drilling are optimized with an objective to minimize burr height.

Table 2.Detail of design factors

| Design factors | Unit | Levels | | |
|---|---|---|---|---|
| | | 1 | 2 | 3 |
| Cutting velocity (A) | m/min | 12.5 | 20 | 32 |
| Feed (B) | mm/rev | 0.032 | 0.08 | 0.125 |
| Machining environment (C) | ----- | Dry | wet with water | wet with soluble oil |

### *3.3. Designing for experiments*

Following Taguchi method, an orthogonal array was chosen to lower experimental runs for determining optimal process parameters. In this experimental work, an $L_{27}$ orthogonal array (needing 27 experimental runs) was chosen. Table 3 shows the orthogonal array in detail. Column 1 of the table is assigned to cutting velocity (A). 2nd column is for feed (B). 5th column is corresponding to machining environment (C). Remaining columns are related to interactions between chosen three factors as shown in Table 3.

Table 3.Detail of $L_{27}$orthogonal array (OA)

| Trial No | Column numbers 1 (A) | 2 (B) | 3 (AxB) | 4 (BxA) | 5 (C) | 6 (AxC) | 7 (CxA) | 8 (BxC) | 9 - | 10 — | 11 (CxB) | 12 — | 13 — |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 3 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 4 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 |
| 5 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 1 | 1 | 1 |
| 6 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 2 | 2 |
| 7 | 1 | 3 | 3 | 3 | 1 | 1 | 1 | 3 | 3 | 3 | 2 | 2 | 2 |
| 8 | 1 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 3 | 3 | 3 |
| 9 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 |
| 10 | 2 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| 11 | 2 | 1 | 2 | 3 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 |
| 12 | 2 | 1 | 2 | 3 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 |
| 13 | 2 | 2 | 3 | 1 | 1 | 2 | 3 | 2 | 3 | 1 | 3 | 1 | 2 |
| 14 | 2 | 2 | 3 | 1 | 2 | 3 | 1 | 3 | 1 | 2 | 1 | 2 | 3 |
| 15 | 2 | 2 | 3 | 1 | 3 | 1 | 2 | 1 | 2 | 3 | 2 | 3 | 1 |
| 16 | 2 | 3 | 1 | 2 | 1 | 2 | 3 | 3 | 1 | 2 | 2 | 3 | 1 |
| 17 | 2 | 3 | 1 | 2 | 2 | 3 | 1 | 1 | 2 | 3 | 3 | 1 | 2 |
| 18 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 2 | 3 | 1 | 1 | 2 | 3 |
| 19 | 3 | 1 | 3 | 2 | 1 | 3 | 2 | 1 | 3 | 2 | 1 | 3 | 2 |
| 20 | 3 | 1 | 3 | 2 | 2 | 1 | 3 | 2 | 1 | 3 | 2 | 1 | 3 |
| 21 | 3 | 1 | 3 | 2 | 3 | 2 | 1 | 3 | 2 | 1 | 3 | 2 | 1 |
| 22 | 3 | 2 | 1 | 3 | 1 | 3 | 2 | 2 | 1 | 3 | 3 | 2 | 1 |
| 23 | 3 | 2 | 1 | 3 | 2 | 1 | 3 | 3 | 2 | 1 | 1 | 3 | 2 |
| 24 | 3 | 2 | 1 | 3 | 3 | 2 | 1 | 1 | 3 | 2 | 2 | 1 | 3 |
| 25 | 3 | 3 | 2 | 1 | 1 | 3 | 2 | 3 | 2 | 1 | 2 | 1 | 3 |
| 26 | 3 | 3 | 2 | 1 | 2 | 1 | 3 | 1 | 3 | 2 | 3 | 2 | 1 |
| 27 | 3 | 3 | 2 | 1 | 3 | 2 | 1 | 2 | 1 | 3 | 1 | 3 | 2 |

## 4. Experimental results and discussion

### *4.1 Discussion on Experimental Observation*

Drilling experiments were done following orthogonal array design to find out the influence of process variables on burr height. Effects of cutting velocity, feed and machining environment on drilling burr height were studied, and experimental results showing comparison between burr height and types observed for both of the cases (with back-up support and without any support) are shown in Table 4.

Table 4 illustrates average burr height observed, and type of burr formed under 27 experimental runs in both the considered circumstances. It is observed that burr formed with back up support is of uniform type in all experimental runs having lesser height than that without using a support. At low feed of 0.032 mm/rev (level 1), type of burr formed is drill cap type in dry condition (level 1), while under wet with water (level 2) condition, uniform burr is noticed; drill cap, crown or uniform burrs are formed under wet with soluble oil condition(level 3) at different cutting velocities. In fact, for this aluminium alloy in dry condition, always drill cap type burr is observed (Fig. 1) in normal drilling process though few of them are dislodged and not seen in figure. Under the two wet conditions chosen for the experimental work, either drill cap, or crown, or uniform burr is noticed (Fig. 1). At a moderate velocity of 20m/min (level 2), low feed (level 1) and wet with water (level 2) condition, burr height is found to be quite low in the present experimental investigation for both of the cases mentioned. But back-up support has provided a consistent result by giving low burr height in the range of 0.16-0.3mm for different sets of environment, feed and cutting velocity.

Table 4. Experimental results for burr height with back up support showing comparison with that of any support

| Run nos. | Process parameters in coded value | | | Without any back-up support | | With back up support | | S/N ratios for back up support burr height (dB) |
|---|---|---|---|---|---|---|---|---|
| | Cutting velocity (A) | Feed (B) | Environment (C) | Burr height (mm) | Burr type observed | Burr height (mm) | Burr type observed | |
| 1 | 1 | 1 | 1 | 4.5 | Drill cap | 0.4 | Uniform in all the runs | 7.9588 |
| 2 | 1 | 1 | 2 | 0.74 | Uniform | 0.26 | | 11.70053 |
| 3 | 1 | 1 | 3 | 9.32 | Crown | 0.6 | | 4.436975 |
| 4 | 1 | 2 | 1 | 4.5 | Drill cap | 0.72 | | 2.85335 |
| 5 | 1 | 2 | 2 | 5.88 | Crown | 0.3 | | 10.45757 |
| 6 | 1 | 2 | 3 | 9.6 | Crown | 0.66 | | 3.609121 |
| 7 | 1 | 3 | 1 | 4.5 | Drill cap | 0.5 | | 6.0206 |
| 8 | 1 | 3 | 2 | 7.58 | Crown | 0.4 | | 7.9588 |
| 9 | 1 | 3 | 3 | 6.1 | Crown | 0.7 | | 3.098039 |
| 10 | 2 | 1 | 1 | 4.5 | Drill cap | 0.5 | | 6.0206 |
| 11 | 2 | 1 | 2 | 1.06 | Uniform | 0.2 | | 13.9794 |
| 12 | 2 | 1 | 3 | 4.5 | Drill cap | 0.4 | | 7.9588 |
| 13 | 2 | 2 | 1 | 4.5 | Drill cap | 0.7 | | 3.098039 |
| 14 | 2 | 2 | 2 | 8.22 | Crown | 0.3 | | 10.45757 |
| 15 | 2 | 2 | 3 | 4.5 | Drill cap | 0.6 | | 4.436975 |
| 16 | 2 | 3 | 1 | 4.5 | Drill cap | 0.6 | | 4.436975 |
| 17 | 2 | 3 | 2 | 7.84 | Crown | 0.16 | | 15.9176 |
| 18 | 2 | 3 | 3 | 7.64 | Crown | 0.64 | | 3.876401 |
| 19 | 3 | 1 | 1 | 4.5 | Drill cap | 1.3 | | -2.27887 |
| 20 | 3 | 1 | 2 | 4.5 | Uniform | 0.48 | | 6.375175 |
| 21 | 3 | 1 | 3 | 1.3 | Uniform | 0.48 | | 6.375175 |
| 22 | 3 | 2 | 1 | 4.5 | Drill cap | 1.22 | | -1.7272 |
| 23 | 3 | 2 | 2 | 9.36 | Crown | 0.3 | | 10.45757 |
| 24 | 3 | 2 | 3 | 1.32 | Uniform | 0.4 | | 7.9588 |
| 25 | 3 | 3 | 1 | 4.5 | Drill cap | 0.9 | | 0.91515 |
| 26 | 3 | 3 | 2 | 1.88 | Uniform | 0.44 | | 7.130946 |
| 27 | 3 | 3 | 3 | 6.5 | Crown | 0.4 | | 7.9588 |

Use of back-up support eliminates the drill to exit freely from the workpiece surface. As the support provided, burr formation at the exit edge of the specimen is also expected to be lowered. Low feed also is supposed to give low burr height due to less thrust and torque requirement. Dry condition generates high machining temperature and may cause softening of the workpiece material ahead of drilling and gives large burr size through large plastic deformation due to more ductility of the work-chip material. Therefore, wet condition shows less burr height expectedly due to less ductility, and hence, less plastic deformation of the workpiece at somewhat low temperature. A back-up support provides necessary support to workpiece during tool exiting, and this may be the reason of lesser burr height.

### *4.1. Analysis of signal-to-noise ratio*

In the present investigation, analysis on S/N ratio was done with burr height as the performance characteristic. Calculations were done using Minitab software [33]. As minimization of burr height was the problem, S/N ratio was calculated using LB (Lower the Better) criterion, and is given by:

$$S/N = -10 \log \left(\sum y^2 / n\right) \tag{1}$$

where, y is the observed data and n is the number of observations.

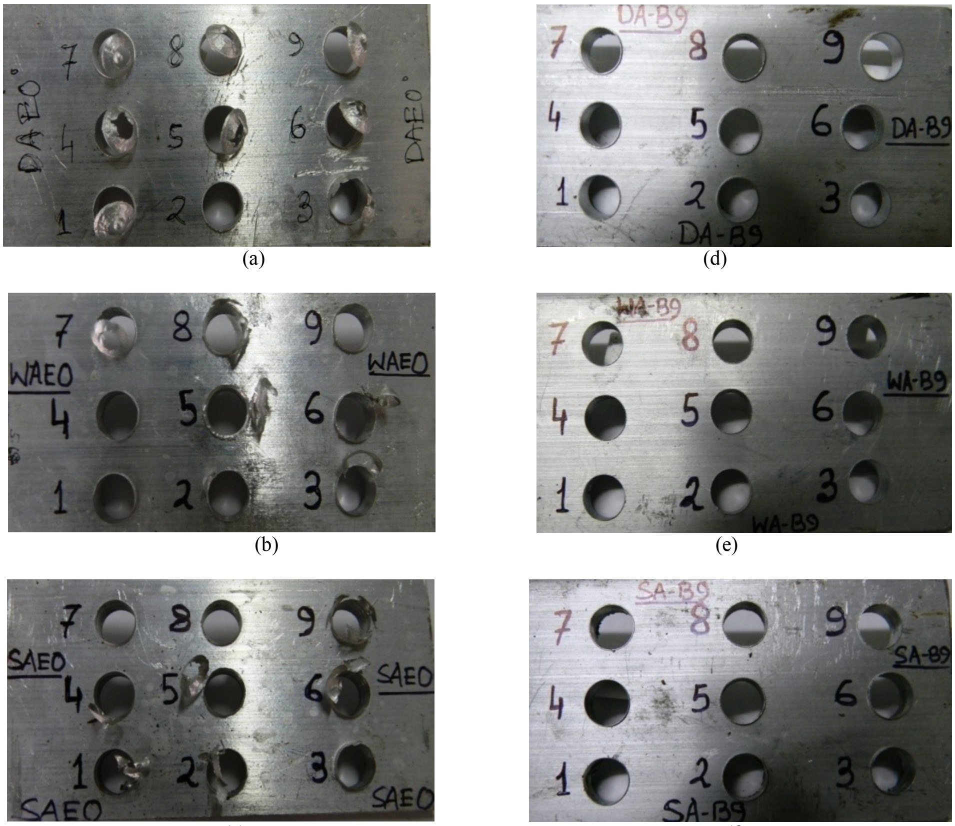



Fig. 1. Photographic views of burrs in environment of Dry (a, d), wet with water (b, e) and Soluble Oil (c, f), with Φ9mm drill without back-up support material (left) and with back-up support material used for aluminium alloy (right) work pieces

Table 5.Response table for S/N ratio.

| Level | A | B | C |
|---|---|---|---|
| 1 | 6.455 | 6.947 | 3.033 |
| 2 | 7.798 | 5.734 | 10.493 |
| 3 | 4.796 | 6.368 | 5.523 |
| Rank | 2 | 3 | 1 |
| Delta | 3.002 | 1.214 | 7.46 |

Total mean S/N ratio=6.349667dB

Burr height obtained along with the S/N ratio considering back-up support is shown in Table 4. Averaged S/N ratios for each level of factors, A, B, and C, are indicated in Table 5. The value of delta was computed by subtracting the largest value from the lowest from values in each column.

When there is no much difference in the S/N ratio from one factor setting to the other, the factor is considered insignificant with regard to the performance characteristic. It is seen from Table 5 that machining environment (C) possesses the highest value of delta, indicating the highest influence on reducing burr height of aluminium alloy flats using a back-up support. Main effect plots and interaction effect plots are illustrated in Fig. 2 and Fig. 3 respectively. The main effects plot shows the optimal combination of drilling process parameters to achieve minimum burr height.

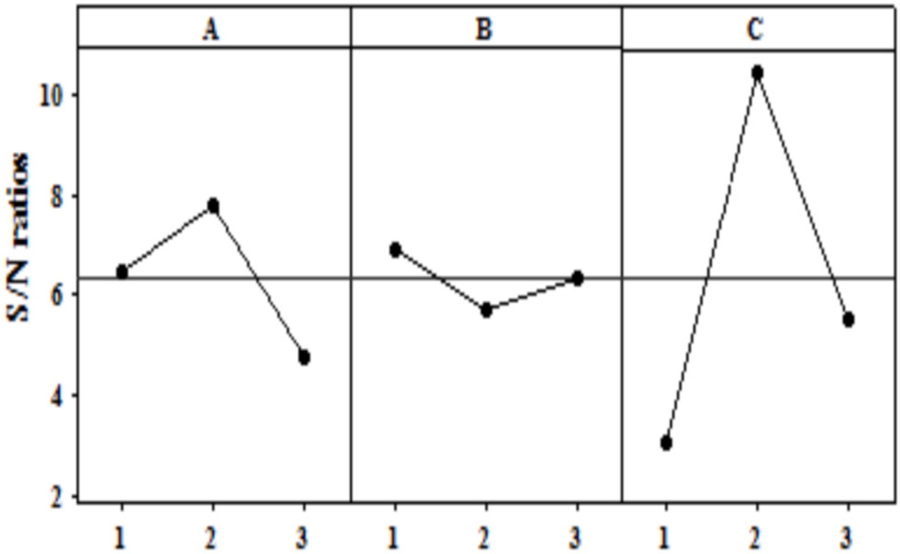
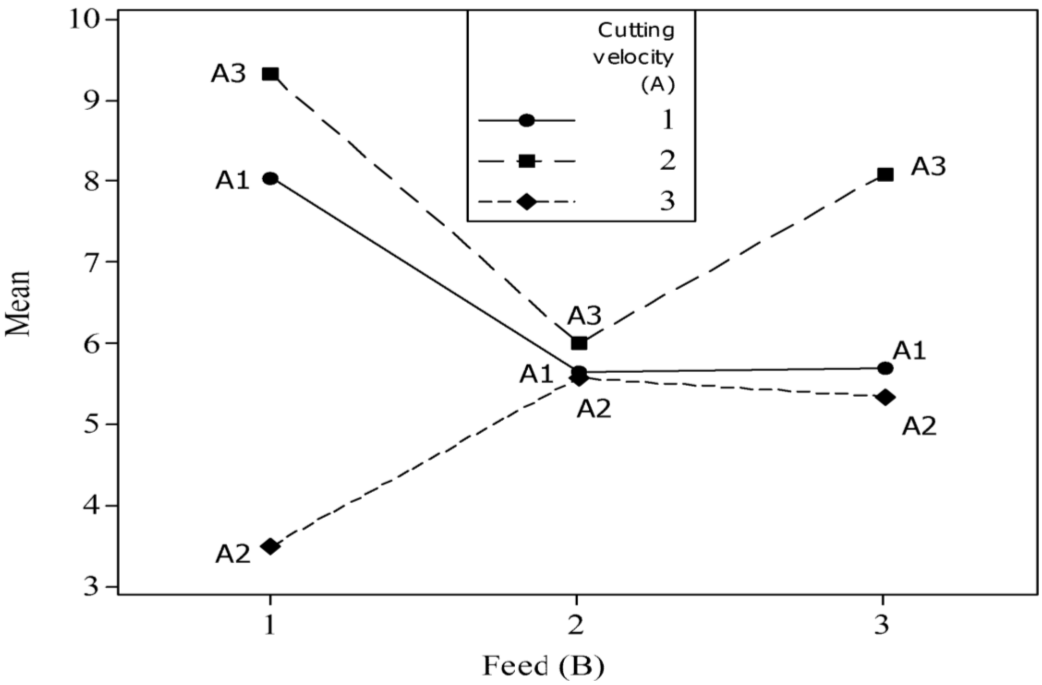


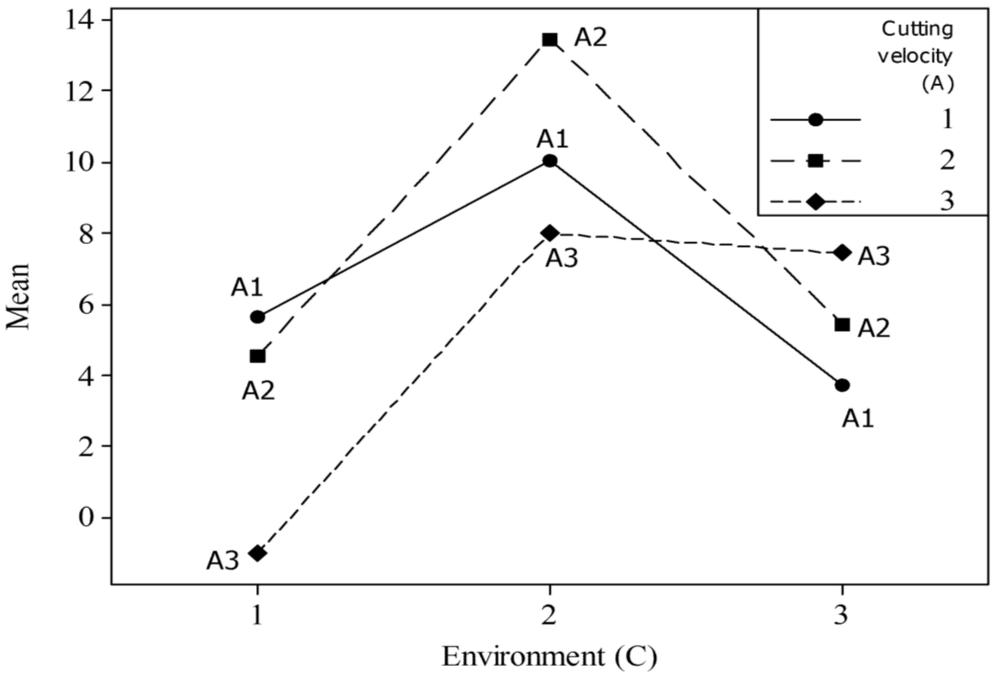

Fig. 2. Main effects plot for signal to noise ratio

As Taguchi method evaluates optimal level combinations by selecting the levels at which S/N ratio is the highest, the optimal parameters combination is obtained as A2B1C2, that corresponds to mid-level of cutting velocity, lower level of feed and mid-level of machining environment. Moreover, the main effects plot shows relative significance of variables on system response given by the slope of the main effect plot for each parameter. The plot with higher inclination corresponds to higher influence. From Fig. 2, it is seen that both the factors A (cutting velocity) and C (machining environment) are more significant than factor B (feed), and factor B has less variation on S/N ratio.

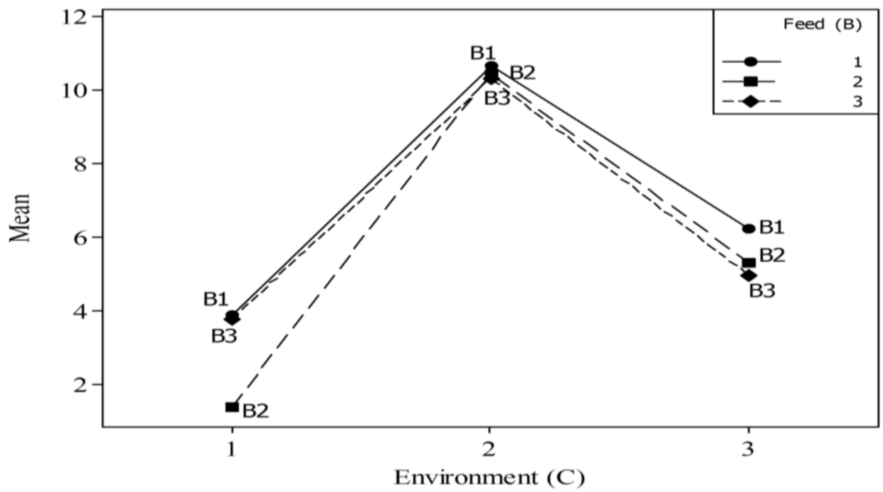
In case of interaction plots, non-parallel lines are noticed. Non-parallel lines indicate presence of interaction while intersecting lines are indicative of the presence of strong interaction. From interaction plots (Fig. 4), it is clear that there is strong interaction between factors A and C (A×C) while moderate interaction is existing within the rest of the factors (A×B and B×C) corresponding to burr height of aluminium alloy specimens with back-up support.


Cutting velocity (A)
1
2
3
A3
A1
A2
Mean
Feed (B)
10
9
8
7
6
5
4
3
1
2
3

(a)


Cutting velocity (A)
1
2
3
A1
A2
A3
Mean
Environment (C)
14
12
10
8
6
4
2
0
1
2
3

(b)




(c)

Fig. 3. Interaction effects plot for mean burr height (a) A with B, (b) A with C, and (c) B with C.

### *4.2. Analysis of variance (ANOVA)*

In the present work, ANOVA is done to find out relative significance of process parameters, and their interactions on burr height in aluminium alloy specimens. Some process parameters might not have considerable effect on burr height. They can be excluded from the optimization model. Percent contribution of variance can be calculated using ANOVA. In this work, ANOVA is performed using S/N ratio as the response, and results are shown in Table 6. The ANOVA table indicates F-values and percentage contributions. By comparing evaluated F-values with that of the table, significance of each factor and their interactions are found out. If the obtained F-value of a parameter or interaction is greater than the table value, then that particular parameter or interaction is considered to have significant influence on the process response.

Table 6 shows that variable C, i.e. machining environment, has the most significant influence on burr height at 99.5% confidence level within the range of machining experiments done. Variable A, i.e. cutting velocity, has much significance at 97.5% confidence level. But parameter B (feed) has less significance on burr height. Among the interactions, the interaction between cutting velocity and machining environment (A×C) has significance at 99%confidence level, and other interactions are not significant.

Table 6. Results of ANOVA

| Source | DOF | SS | MS | F | Cont(%) |
|---|---|---|---|---|---|
| A | 2 | 40.7 | 20.35 | 6.82* | 8.659869 |
| B | 2 | 6.635 | 3.318 | 1.11 | 1.41175 |
| C | 2 | 259.636 | 129.818 | 43.5* | 55.24358 |
| A*B | 4 | 29.217 | 7.304 | 2.45 | 6.216595 |
| A*C | 4 | 101.852 | 25.463 | 8.53* | 21.67138 |
| B*C | 4 | 8.068 | 2.017 | 0.68 | 1.716654 |
| Error | 8 | 23.875 | 2.984 | | 5.07996 |
| Total | 26 | 469.984 | | | 100 |

* Significant parameters ($F_{0.005,2,8}$= 11.042, $F_{0.025,2,8}$= 6.0595 & $F_{0.01,4,8}$= 7.0060)

### *4.3. Confirmation test*

Confirmation test is usually done at the end of the DOE. It is done to verifythe optimum conditions evaluated through analysis with corresponding experimental results. Estimated value of the S/N ratio at the optimum level,$\hat{\eta}$can be obtained as:

$$\hat{\eta} = \eta_m + \sum_{i=1}^{o} (\bar{\eta_i} - \eta_m) \tag{2}$$

where, $\eta_m$ is total mean S/N ratio, and $\eta_i$ is mean S/N ratio at the optimal level. 'o' is the number of main design parameters having significant effect on burr height of aluminium specimens. Comparison of predicted S/N ratio with the experimental one using optimal parameters is shown in Table 7.There is good agreement seen between the two. Improvement in S/N ratio at the optimal condition compared to that at the initial condition is also observed from Table 7. Increase in S/N ratio from the initial test condition to the optimal testing condition is computed to be 3.529dB.It means drilling with back-up support at an optimal condition has about 33% reduction in burr height compared to that at the initial condition. In other words, experimental results confirm good estimate of optimized drilling process parameters.

Table 7.Results of confirmation test

| | | Optimal Parameter | |
|---|---|---|---|
| | Initial Parameter | Predicted | Experimental |
| Level | A2B2C2 | A2B1C2 | A2B1C2 |
| Burr height | 0.3 | | 0.2 |
| S/N ratio | 10.45757491 | 12.538 | 13.97940009 |

Improvement of S/N Ratio=3.529dB

## 5. Conclusion

In the present work, orthogonal array design of Taguchi is applied to minimize burr height of aluminium alloy flats by optimizing three drilling process parameters viz. cutting velocity, feed and machining environment. Height of burr observed through providing back-up support is quite less compared to that without using a back-up support. Optimum testing condition using a back-up support is obtained to reduce burr height by about 33%. The analysis of variance reveals machining environment and cutting velocity to have good influence on burr height for aluminium alloy. Interaction between cutting velocity and machining environment (A×C) is found significant in controlling burr height in drilling with the use of back-up support.

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